

## **VHF Injector Pumping Slot RF Shielding Effectiveness\***

John Staples

Lawrence Berkeley National Laboratory  
1 Cyclotron Rd., Berkeley CA 94720, USA

**Disclaimer:** This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

\*This work was supported by the Director, Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

## VHF Injector Pumping Slot RF Shielding Effectiveness

John Staples, LBNL

8 August 2007

The effectiveness of the shielding of the pumping slots is calculated for two radial depths of the slots with Mafia-2 and compared to a simple recipe that calculates the RF attenuation in a slot.

CBP Technical Note 378 describes the pumping configuration of the 100 MHz VHF photoinjector. The cavity is surrounded by 36 slots, 4.9 cm wide, separated by bars, also 4.9 cm wide. The radial depth of the bars controls the attenuation of the RF from the cavity proper to the annular plenum outside the bars where the getter pumps are located.

This note describes calculations of the level of RF fields in the plenum for two different values of the radial depth of the bars and two different values of the spacing between the outer dimension of the bars and the outer plenum wall. Figure 1 shows the cavity with pumping slots and pumping plenum.

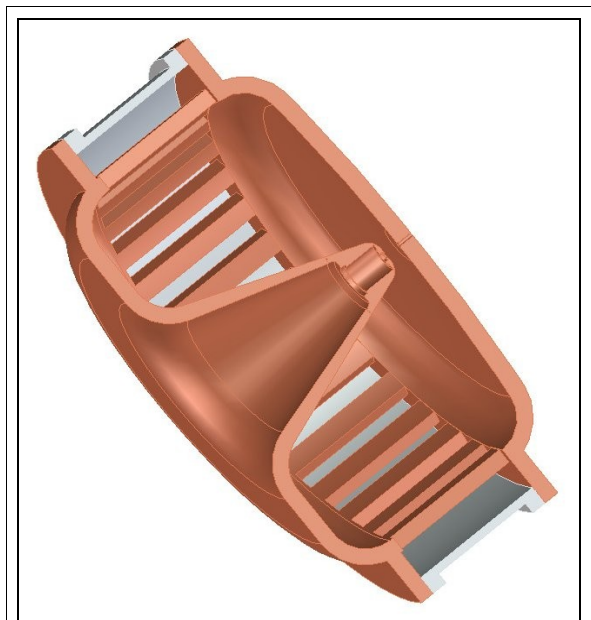


Figure 1. Cavity with Pumping Slots

Three combinations of bar/plenum geometry were investigated: (dimensions in centimeters)

Case	Bar Depth	Bar to Outer Wall	Calculated Attenuation
A	4	4	22 db
B	4	10	22 db
C	9	5	50 db

The attenuation of both the electric field and magnetic field is calculated from the inner surface of the bar to the outer surface, as well as the distribution of the fields in the plenum region.

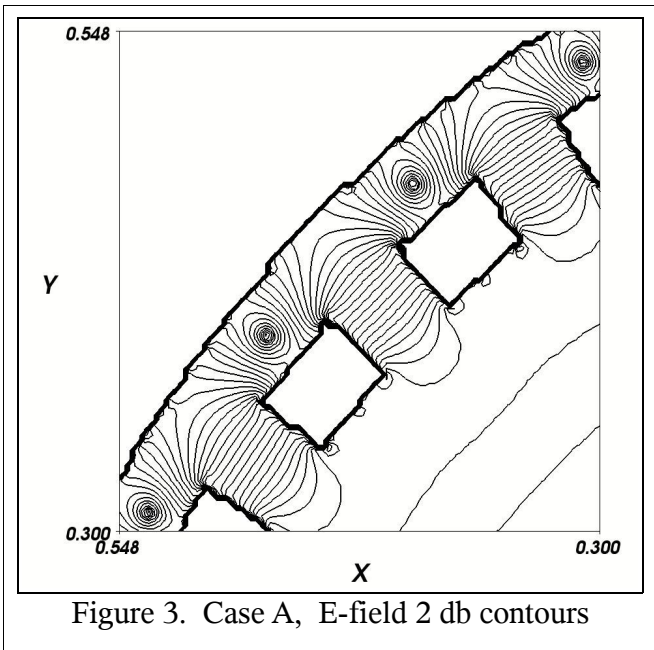
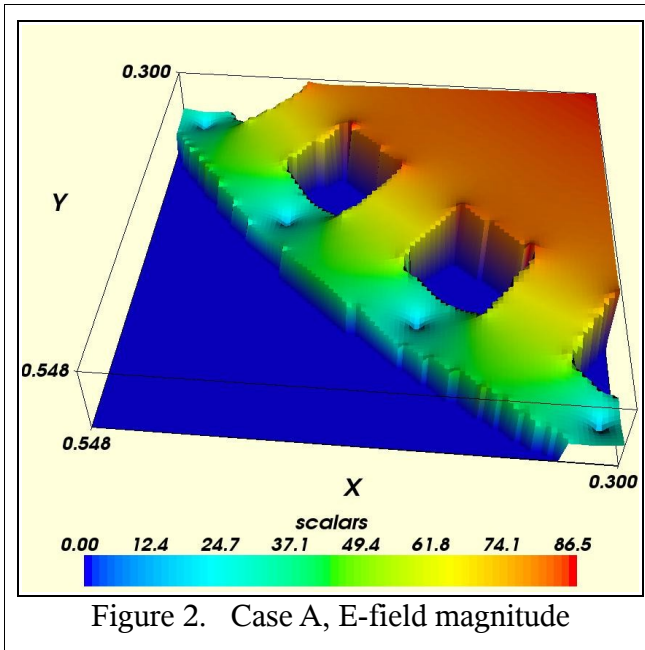
The attenuation may also be calculated analytically as a waveguide beyond cutoff, and is indicated in the above table. A useful expression is<sup>1</sup>

$$Atten[db] = 54.5 \frac{d}{\lambda_c} \left[ 1 - \left( \frac{\lambda_c}{\lambda} \right)^2 \right]^{1/2}$$

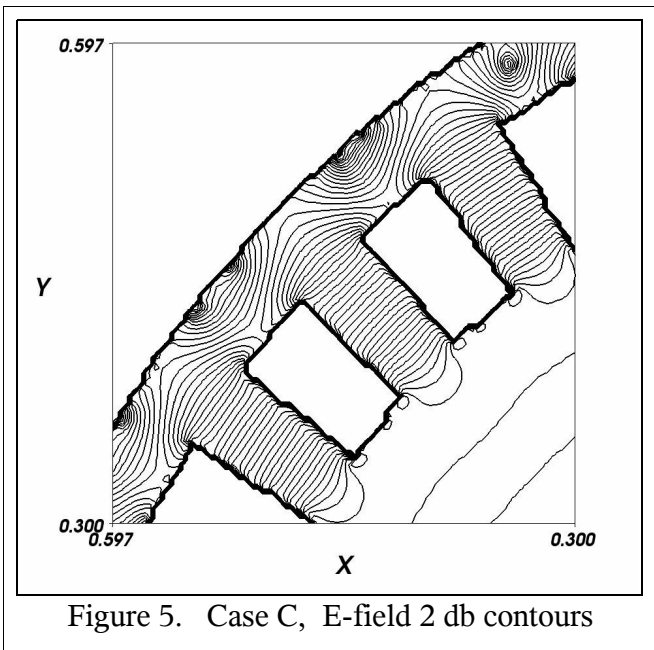
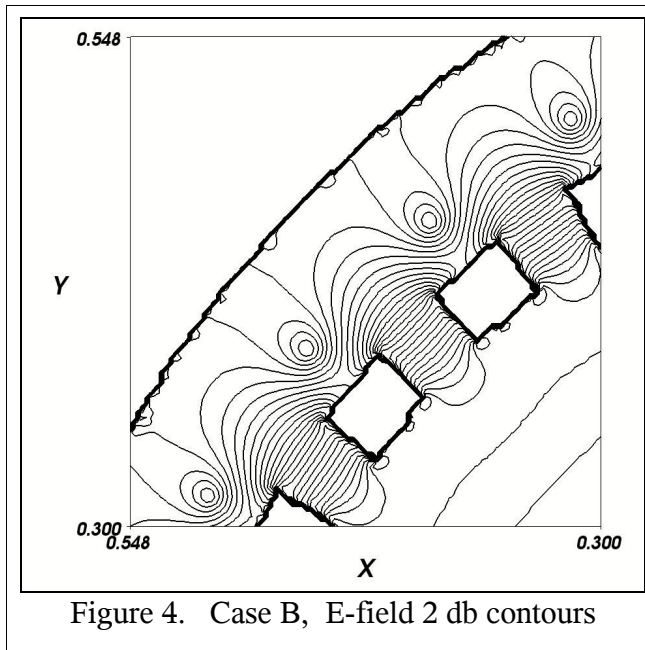
where  $d$  is the depth of the slot,  $\lambda$  the operating wavelength and  $\lambda_c$  the cutoff wavelength for a waveguide of height  $b$ . In this case,  $b = 4.9$  cm, and  $\lambda_c = 2b = 9.8$  cm, corresponding to a cutoff frequency of 3.1 GHz. The operating wavelength  $\lambda$  at 106.6 MHz is 281.4 cm.

1 Reference Data for Radio Engineers, p. 25-6.

These attenuation figures are compared to those calculated with Mafia-2 for the same 3-D geometries.



Figures 2 and 3 illustrate the logarithm of the magnitude of the electric field in the outer pump slot region of cavity, case A, expressed in dB. The attenuation of the field along the depth of the slot is seen to be about 11 contours, or 22 dB, consistent with a waveguide-beyond-cutoff. Calculation of the magnetic field (not shown) give identical results in the slots. There is a dip in the field magnitude at points directly behind the bars, which may be a good spot for the getter pumps to be located.



Figures 4 and 5 show the results for the electric field magnitude for cases B and C with similar results and agreement with the waveguide-beyond-cutoff model.

The magnetic field on the inner surface of the bar in cases A and B results in a power density of less than 3 watts/cm<sup>2</sup>. At a 22 dB attenuation, the power density on the outer radius of the bar would be about a factor of 158 less, or about 0.019 watts/cm<sup>2</sup>.

Even in the worst case for case A, the field at the outer wall is at least another 10 dB down, or at least 32 dB from the inner wall, for a power dissipation will be less than 2 mW/cm<sup>2</sup>.

The introduction of getter pumps in the plenum region should not affect the attenuation through the pumping slots, but it will redistribute the fields and thus the power density on the surfaces in the plenum. The walls of the plenum need not be copper, and a more lossy material such as aluminum or stainless steel may be advisable to damp higher modes that may possibly be excited.

To calculate the RF power dissipation on a getter pump, assume that a pump is 35 cm long with a smoothed radius of 2 cm, for a surface area of 440 cm<sup>2</sup>. For an average attenuation of the cavity internal fields of 30 dB for case A in the plenum area, one getter pump will absorb about 1.3 watts of RF power.

Therefore, the slot depth of 4 cm (case A) seems to be acceptable.